Residential Fuel Cell Demonstration by the Delaware County Electric Cooperative, Inc.

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This presentation does not contain any proprietary or confidential information

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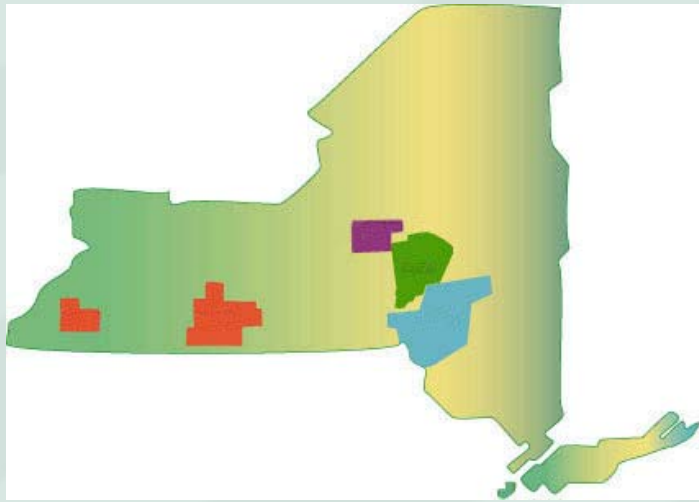
Delaware County Electric Cooperative, Inc.

Company Overview

- Headquarters: Delhi, NY
- Geographic Area Served:
  - Counties: Delaware, Schoharie, Otsego, Chenango
- 800 miles of distribution lines
- 5,000 member/customers
- 30 Employees
- System Load: ~15MW peak
- Member of National Rural Electric Cooperative

Association (NRECA)

•Vital utility provider to the greater Catskill Mountain area



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Project Overview

Timeline

- Start: February 2004
- Finish: January 2007
- 70% Complete

Budget

- Total project $637,000
  - DOE $294,000
  - Co-funding $343,000
- Funding in FY05
  - $140,000
- Funding for FY06
  - $130,000

Barriers Addressed

- DOE designation “I”
- Hydrogen and electricity co-production
  - ➢Cost and durability not statistically validated
  - ➢Permitting, codes, and standards not established for fuel cells in or around buildings
  - ➢Lack of operational and maintenance experience

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Partners/Collaborators

- ***Major funding:***
- Department of Energy Golden Field Office
- New York State Energy Research and Development Authority (NYSERDA)
- National Rural Electric Cooperative Association (NRECA) / Cooperative Research Network (CRN)
- Energy Now! Inc.

- ***Technical contribution:***
- Gaia Power Technologies, Inc.
- Sandia National Laboratories
- Mirabito Fuel Group
- New York Power Authority
- Plug Power, Inc.

- ***Education and outreach:***
- State University of New York College of Technology at Delhi (SUNY Delhi)
- Lansing Community College (Michigan)
- NRECA / CRN

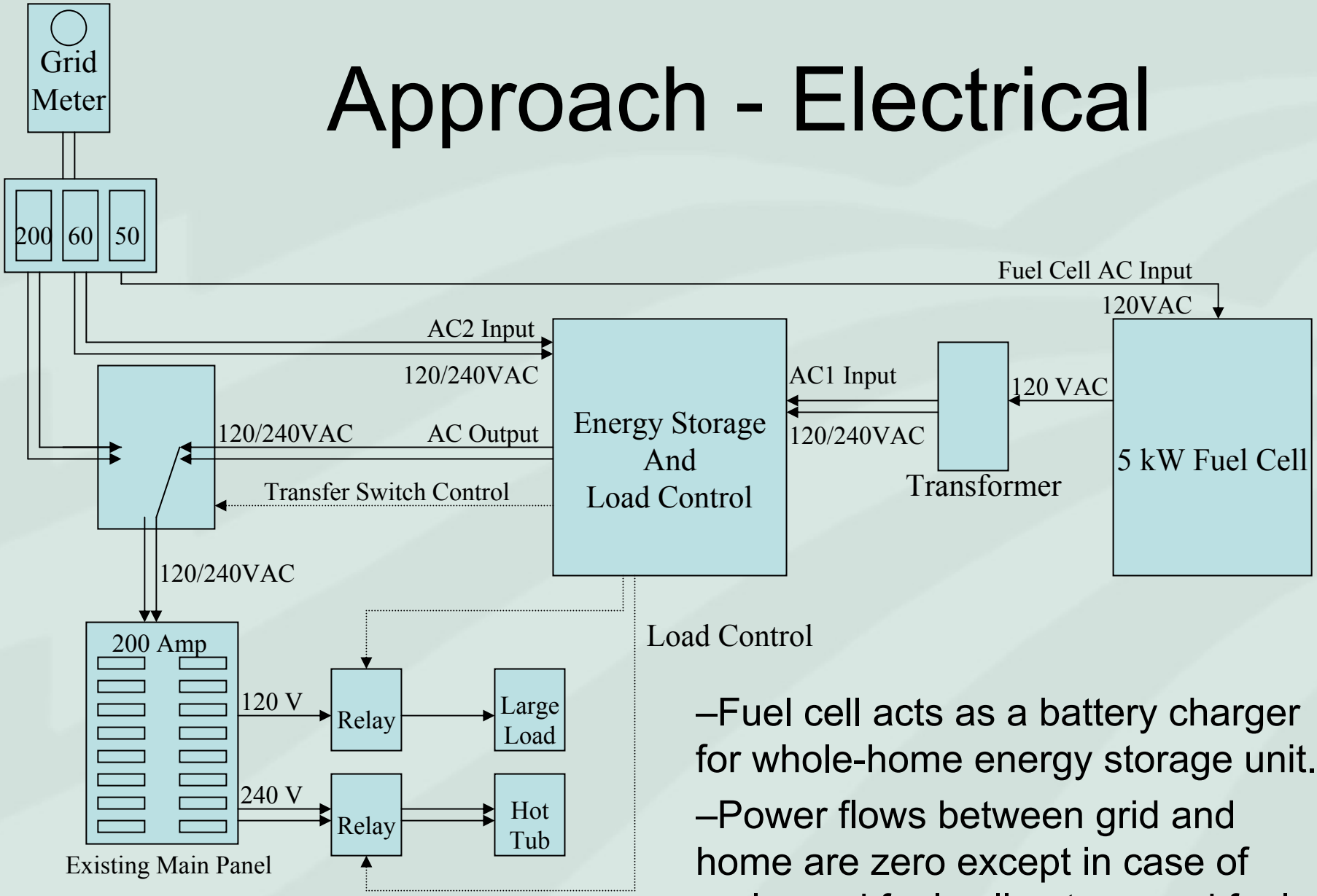
- ***Data analysis and reporting:***
- EnerNex Inc.
- Energy Now! Inc.
- NRECA / CRN
- SUNY Delhi

Objectives

- ***Demonstrate viability of grid-independent home***
  - typical upstate NY residence
  - total electrical energy needs met by fuel cell
  - intelligently managed energy storage
  - in-home load control
  - Increased efficiency through thermal recovery

- ***Validate objectives of propane fueled hydrogen fuel cells for edge-of-grid residences via a field trial demonstration***
  - measure and report technical performance
  - provide raw cost data and economic viability analysis
  - document maintenance and operations concept enhancements specific to residential fuel cells
  - share safety related vulnerabilities analysis and lessons learned
  - promote education of state and local consumers

Approach - Electrical



–Fuel cell acts as a battery charger for whole-home energy storage unit.

–Power flows between grid and home are zero except in case of prolonged fuel cell outage and fuel cell startup.

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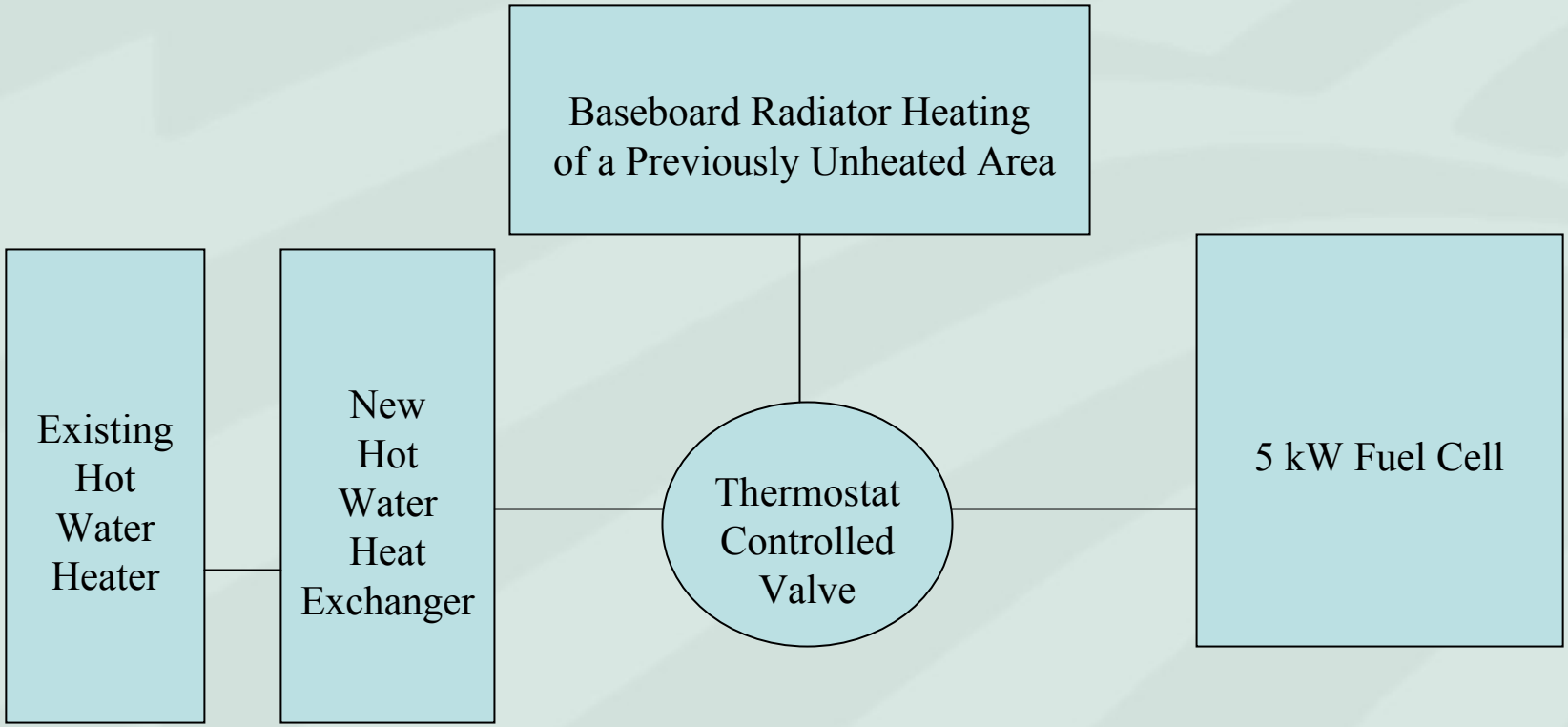
Approach – Thermal



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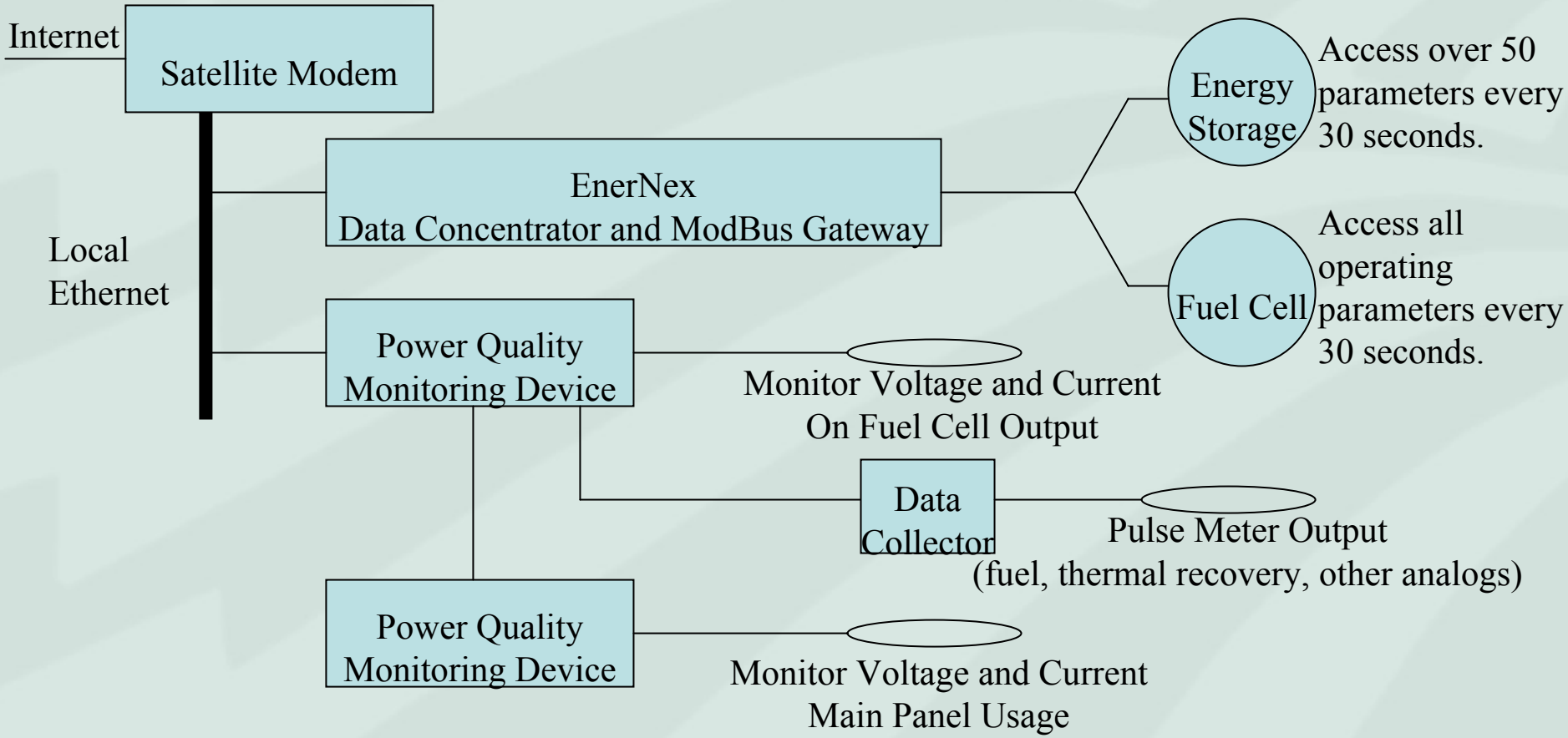
Approach – Data Monitoring



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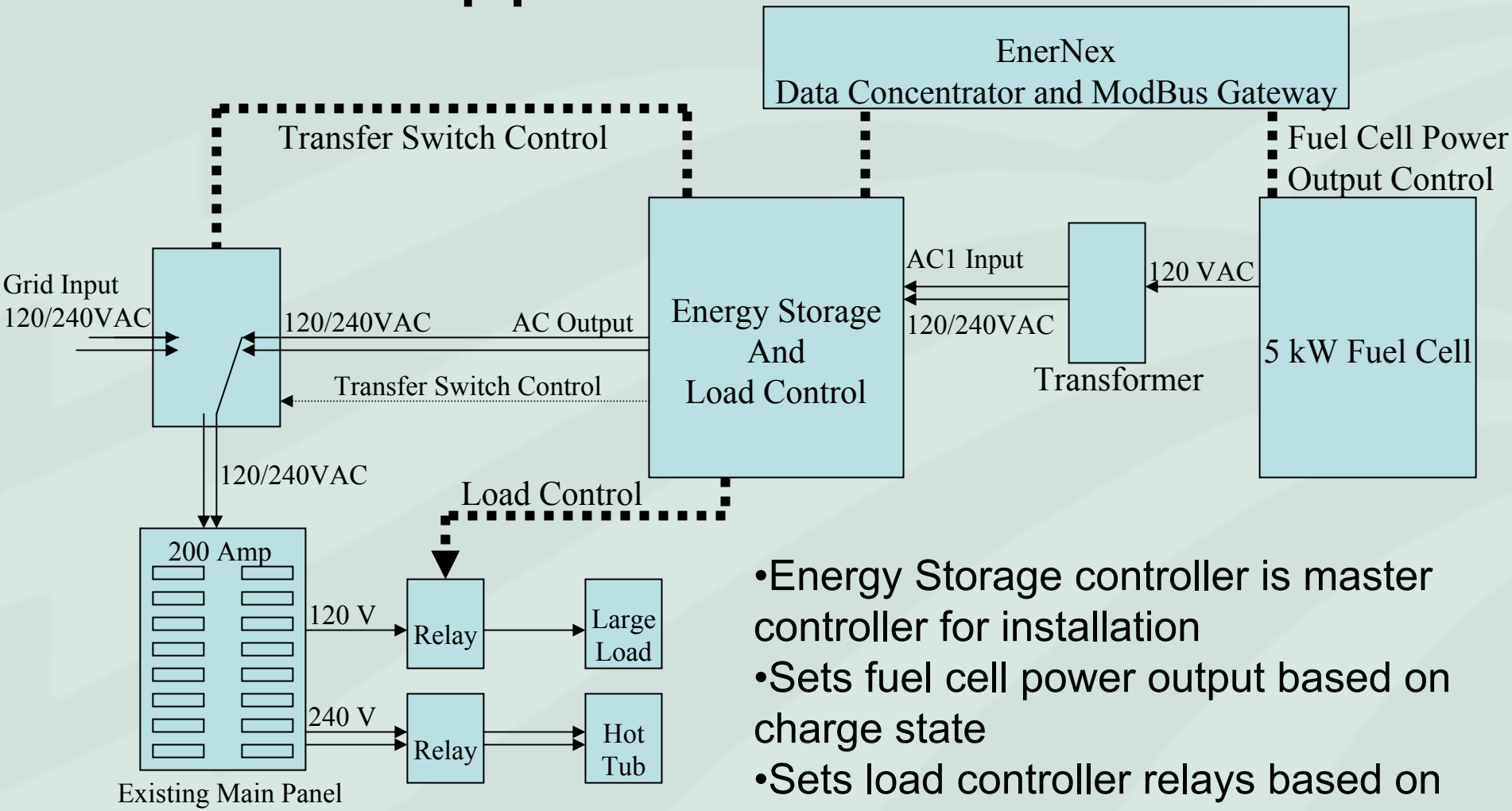
Approach – Control



- Energy Storage controller is master controller for installation
- Sets fuel cell power output based on charge state
- Sets load controller relays based on inverter output to loads
- Actuates transfer switch in the event of system overload

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Outreach Approach

- Educate general public, extension service, and policy makers through news media, press events, and site tours
- Target industry and academia through conference presentations and publications
- Target local and regional educators with seminar at local college
- Target rural electric cooperatives through out the nation through the National Rural Electric Cooperative (NRECA) fuel cell program

Technical Accomplishments 2005

- Detailed design
- Installation of fuel cell, energy storage, thermal recovery, high speed data logging equipment, communications link
- Commissioning
- 10 months of operations and maintenance experience
- Integrated load sensing, in-home load control, and fuel cell control into energy storage controller

5 kW PEM Fuel Cell

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11 kW / 600 Ah Energy Storage

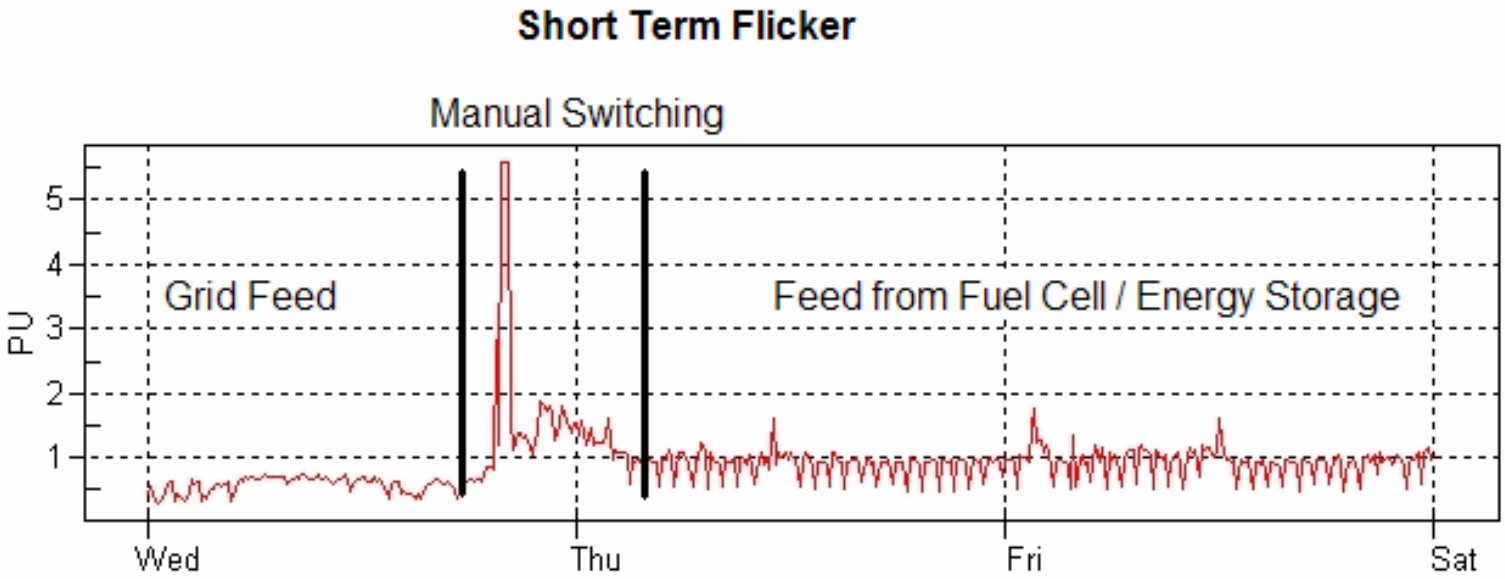
Technical Challenge – Infant Stack Failure

- Liquid petroleum gas (propane) distributors introduce ~2500 ppm by volume of methanol into newly installed propane tanks
- methanol is preferentially physically absorbed on the surface of alumina-based desulfurization materials
- reduced desulfurization performance results in sulfur breakthrough and stack contamination/failure
- subsequent stack performance fine after stack and desulfurization tank replacement indicating methanol concentrations are reduced to tolerable levels
- fuel cell vendor confirms that infant stack mortality has been observed in every propane installation involving a new tank (utilizing alcohol to de-water tank)

Infant Stack Failure - Solutions

- calculate the amount of methanol required for de-watering of tank and add no more than necessary
- make desulfurization bed larger or change earlier and more frequently during startup phase
- use an absorbent material that would allow methanol to pass through but would preferentially absorb sulfur containing compounds (difficult / expensive)
- introduce a low-cost sacrificial pre-filter to absorb water and methanol (e.g., high porosity alumina)

Technical Challenge – Short Term Flicker

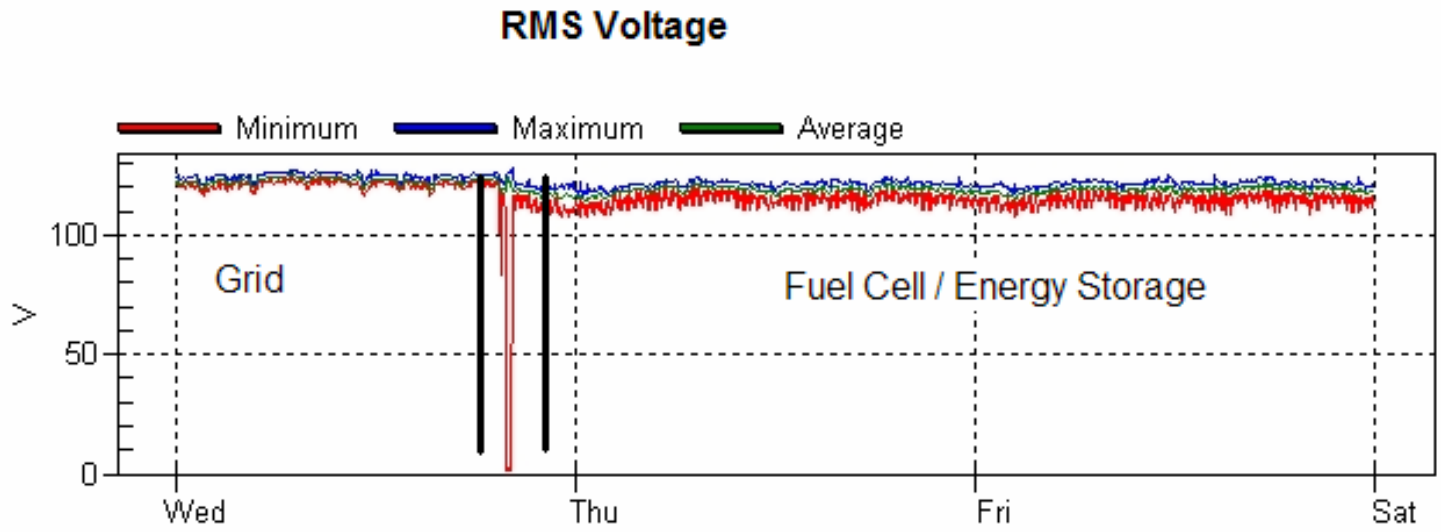


- short term flicker becomes problematic to human perception at roughly 1 PU
- significant short term flicker seen with fuel cell and energy storage compared to grid

Flicker – Assessing Source

- slow response time of the inverters to load changes
- relative weakness of distributed generation source as compared to grid
- frequent voltage manipulation by inverters to control charge state
- presence of large loads with short cycling periods

Flicker Solutions



- capacitors on the load side of the inverters were considered but this is not a transient problem or a reactive power problem – it is a real power problem
- must stop it at its source
  - reduce startup currents on large loads
  - reduce cycling of loads and battery charger

Technical Challenge – Thermal Recovery

- Thermal recovery system required excessive conservatism to avoid over-cooling the fuel cell
- Space heating thermostat had to be turned down
- Fuel cell control system must be improved to become sufficient to protect itself from over-cooling

Consumer Education Progress

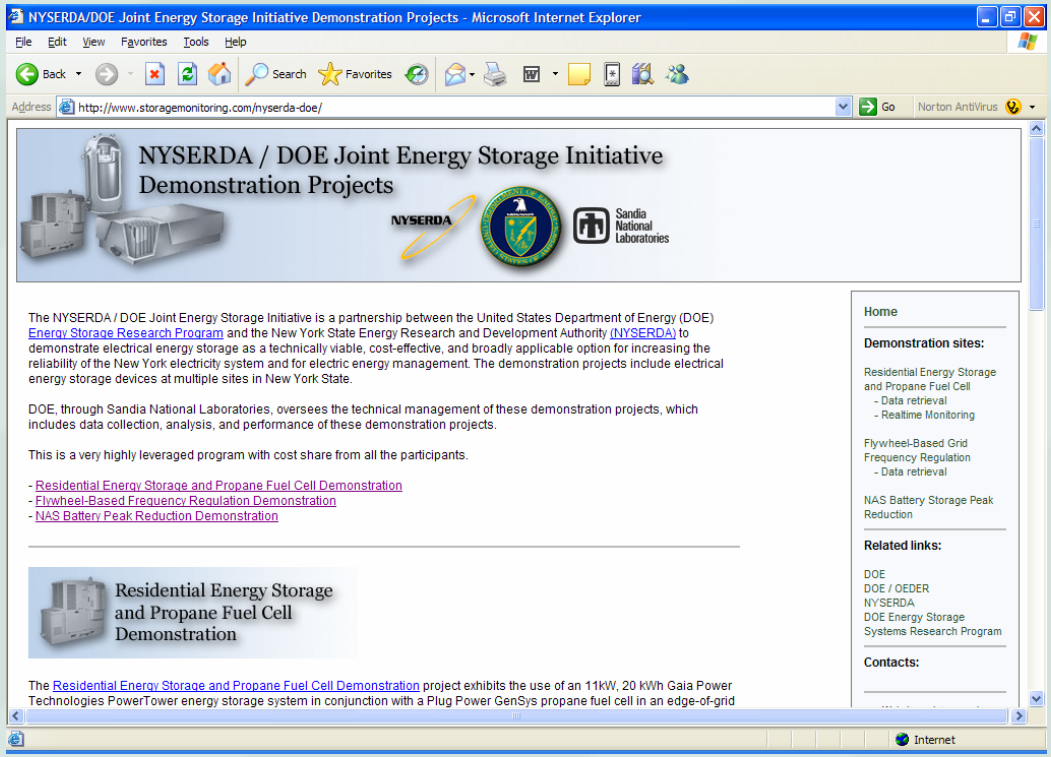
- Press event in August 2005
  - extensive newspaper, radio, and television coverage throughout upstate NY
  - highlighted the role of fuel cells and energy storage in our future energy systems
- June 2006 energy technology home tour sponsored by Cornell Cooperative Extension

Academic Outreach Progress

- One-day fuel cell and energy storage seminar co-hosted by SUNY Delhi and Lansing Community College (MI) on May 15, 2006
- Target audience includes educators and energy professionals in upstate New York
- Goal to increase awareness and curricula development

Knowledge Transfer Progress

- Public Internet access to project data
- http://www.storagemonitoring.com/nyserda-doe/
- Real time and historical data recordings available for many performance parameters and settings



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Future Work

- Final month of fuel cell data collection June 2006
- Decommission fuel cell June 2006
- Continue energy storage data collection through December 2006
- Complete technical analysis
  - O&M history, efficiency, power quality reporting January 2007

Project Summary

Relevance: Project provides a real-world basis, along with sister projects, for improvements to commercial product offerings, system integration design for residential use, installation techniques, operations and maintenance.

Approach: Design, install, operate, and maintain a combined fuel cell and energy storage implementation that fully meets the electrical needs of a typical home. Provide transparent access to performance data and share lessons learned through peer reviewed publications and other presentations.

Progress: Installation, operation, data collection, and outreach programs all proceeding as scheduled.

Tech Transfer / Collaborations: Partnerships within industry, government, academia, and non-profit entities to facilitate knowledge transfer.

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Back-up Slides

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Responses to Reviewers' Comments

- Transparency required for performance data (good or bad)
  - The project has made all performance data and power quality data available to the general public at http://www.storagemonitoring.com/nyserda-doe/
- Method for economic analysis unclear
  - Economic analysis at conclusion of project will focus on avoided energy costs versus capital and O&M costs
  - Further analysis will focus on right-sizing the fuel cell and energy storage device
- Data point of one – need parallel project(s)
  - The National Rural Electric Cooperative is providing technology transfer assistance and they are compiling data from residential fuel cell demonstrations around the nation. There will be a large body of data available to NRECA to assist them in drawing conclusions.
  - There is an identical energy storage device being used with the same model fuel cell (natural gas) by our sister project in New York, NY.
- Concern about O&M costs and complexity
  - This was a valid concern that we underestimated the complexity and difficulty of getting the fuel cell back up and running quickly in the event of a failure. Extended down times resulted on multiple occasions. However, the financial burden was not overwhelming.

Publications and Presentations

- Peer reviewed
  - M. Hilson Schneider, I. Olsen, Residential Energy Storage and Propane Fuel Cell Demonstration Project by the Delaware County Electric Cooperative, Inc., Proceedings of the Electrical Energy Storage Applications and Technologies Conference, October 2005, California.
  - M. Hilson Schneider, W. Davis, Propane Fuel Cell and Energy Storage Demonstration by the Delaware County Electric Cooperative, Inc., Abstract accepted for the 2006 LP Gas Global Technology Conference, Chicago, Illinois, October 2006.

Publications and Presentations

- Other
  - –May 2005 – presentation by G. Starheim to the Northeast Rural Electric Cooperative Association
  - –August 2006 – presentations by project partners to large group of public, elected officials, and members of the press at the project press event
  - –2005,2006 – presentations to 6 local school districts
  - –September 2005 – presentation by M. Hilson Schneider to 400 local members of the community at the DCEC annual meeting
  - –May 2006 – One day seminar presented at SUNY Delhi

Critical Assumptions / Issues

- Assumption – Project partner EnergyNow! Inc. will successfully administer our sister project in New York, NY.
- Assumption – Project partner EnerNex Inc. will continue to provide excellent support to our data acquisition and logging activities through the end of the project.
- Assumption – Project partner NRECA will provide the required support during the technology transfer stage of the project after decommissioning.
- We are in frequent communication with these project partners and feel that our partners continue to be fully committed to meeting the needs of the project.